Technical Memorandum

May 1, 2013 STI-909101-5646-TM

To: James Andrews and James Elder, Caltrans

From: Douglas Eisinger and Song Bai

Re: Background material regarding CT-EMFAC and EMFAC-PL consistency

Introduction

This memorandum explains the technical consistency between CT-EMFAC (the Caltrans version of the EMFAC model) and EMFAC-PL (CARB's project-level EMFAC-based support tool). This explanation will help Caltrans and CARB communicate technical information to the U.S. Environmental Protection Agency (EPA) to facilitate EPA's approval of CT-EMFAC for project-level conformity analyses.

On March 6, 2013, EPA published approval of the CARB EMFAC2011 emissions model for use with state implementation plan (SIP) development and transportation conformity (Federal Register 78:44, pp. 14533-14536). In its EMFAC2011 approval, EPA also approved CARB's project-level version of EMFAC2011, called EMFAC-PL. EPA stated

> CARB has developed the EMFAC–PL tool, as a simplified method to extract the appropriate emissions factors for alternative vehicle data and speeds from EMFAC2011 for appropriate projects…. To that end, we are also approving the EMFAC–PL tool for project-level conformity analyses, **and allowing other tools to be approved by EPA, if such alternate project-level tools provide for similar performance in applying EMFAC2011 emissions factors for appropriate projects** [*emphasis added*]. (Federal Register 78:44, p. 14534)

To approve other tools, such as CT-EMFAC, EPA noted that

> EPA would approve any alternate project-level tool through a letter, after completion of its review of model documentation showing consistency with the EMFAC–PL approach. (Federal Register 79:44, p. 14534, Footnote 5)

This memorandum provides CT-EMFAC model documentation showing consistency with the EMFAC-PL approach, to facilitate EPA's approval of CT-EMFAC for transportation conformity assessments.

CT-EMFAC Development History

CT-EMFAC (Version 1.5), based on EMFAC2007, was developed by the University of California, Davis (UC Davis) in 2007 with support from Caltrans and CARB. Subsequent UC Davis versions (Version 2.0, February 1, 2008; Version 2.6, May 29, 2008) improved calculation of diesel-related emissions and corrected a software problem related to modeling San Diego-area emissions. Model documentation for CT-EMFAC versions developed by UC Davis is available at http://aqp.engr.ucdavis.edu/Modeling/Modeling.html. Versions 3.0 and later were developed by Sonoma Technology, Inc. (STI) with permission from UC Davis and with support from Caltrans and the San Diego Association of Governments (SANDAG).

- Version 3.0 (February 19, 2010) added the ability to output diesel exhaust organic gas (DEOG) emissions.
- Version 4.0 (March 26, 2010) added the ability to run multiple project scenarios in a batch mode.
- Version 4.1 (September 20, 2010) added the ability to work with an additional spreadsheet tool, *CT-EMFAC Naphthalene and POM Template.xls*, to estimate naphthalene and polycyclic organic matter (POM) emissions.
- Version 5.0 (April 30, 2013) rebuilt the CT-EMFAC tool using EMFAC2011 data, a new database structure, and updated vehicle classification algorithms. With this version, users can specify trucks in greater detail, as well as more easily model MSAT emissions.

Overlap in Development Processes for CT-EMFAC and EMFAC-PL

STI developed CT-EMFAC Version 5.0 with support from CARB and Caltrans. Throughout the development process, STI worked closely with CARB and Caltrans staff to discuss development strategies, share work plans, and resolve technical issues. During the CT-EMFAC development effort, CARB developed the EMFAC-PL tool. In September 2012, at the request of CARB and Caltrans, STI reviewed and commented on a draft version of EMFAC-PL; for example, STI ran tests to briefly compare outputs from the EMFAC-PL tool and the EMFAC2011 online data tool, and found the outputs to be consistent (differences were due to (1) rounding that occurred during emission factor calculations, and (2) CT-EMFAC's handling of missing data, as discussed later in this document). The STI review assisted CARB in quality assuring EMFAC-PL, and provided CARB and Caltrans an opportunity to ensure that the EMFAC-PL and CT-EMFAC development methods were consistent.

CT-EMFAC Consistency with EMFAC-PL

Underlying Data Consistency and Additional Design Features Built Into CT-EMFAC

CT-EMFAC and EMFAC-PL are based on the same underlying data, originating from EMFAC2011. The discussion that follows illustrates the consistency between the emission factors output from the two tools.

In addition, CT-EMFAC was designed for a transportation project analysis audience and it includes several features that are distinct from EMFAC-PL. These design features simplify generation of project-specific emissions by enabling analysts to more quickly run numerous project scenarios, and to complete federally required air toxics emissions modeling.

1. CT-EMFAC incorporates mobile source air toxics (MSAT) emissions data and algorithms that enable output of MSAT emissions factors and project-level emissions. The CT-EMFAC database includes MSAT speciation data supplied by CARB and EPA, and the MSAT estimation methodologies included in CT-EMFAC were developed in consultation with CARB and EPA. EMFAC-PL does not address MSATs, since MSATs are not an output of the EMFAC2011 model.

2. CT-EMFAC enables analysts to pair project-level emissions factors with project-level travel activity to estimate emissions for individual roadway links. EMFAC-PL does not include a function that allows users to combine project-level activity with emissions factors to produce emissions.

3. CT-EMFAC includes a batch mode that enables analysts to pair project-level emissions factors with project-level travel activity to simultaneously estimate project emissions for multiple cases. The CT-EMFAC batch mode facilitates simultaneous project-level emissions estimation for five analysis scenarios (e.g., base year, future year “x” no-build, future year “x” build, future year “y” no-build, future year “y” build) and up to 100 roadway links per scenario. CT-EMFAC’s integration of emissions factors and travel activity substantially reduces the time needed to complete project analyses.

4. CT-EMFAC readily enables users to specify the composition of project-specific vehicle fleets. The CT-EMFAC graphical user interface helps analysts aggregate EMFAC2011’s 51 individual vehicle technology groups into three vehicle classifications: non-trucks (largely light-duty passenger vehicles), truck 1 (light heavy-duty trucks) and truck 2 (medium heavy-duty and heavy heavy-duty trucks). This design feature retains all of the underlying vehicle classification details from EMFAC2011, but simplifies, from a project analyst’s perspective, how to characterize the project fleet and process vehicle-specific data for emissions modeling.

Figure 1 provides a high-level illustration of how a project analyst would use CT-EMFAC and EMFAC-PL to derive project-level emissions. Figure 1 illustrates that using the EMFAC-PL tool involves data assembly and processing steps that are embedded directly in the CT-EMFAC architecture. **Figure 2** is a flow diagram that illustrates how EMFAC-PL and CT-EMFAC are designed to consistently employ EMFAC2011 data and how CT-EMFAC also incorporates MSAT information and travel activity to produce project-level emissions.

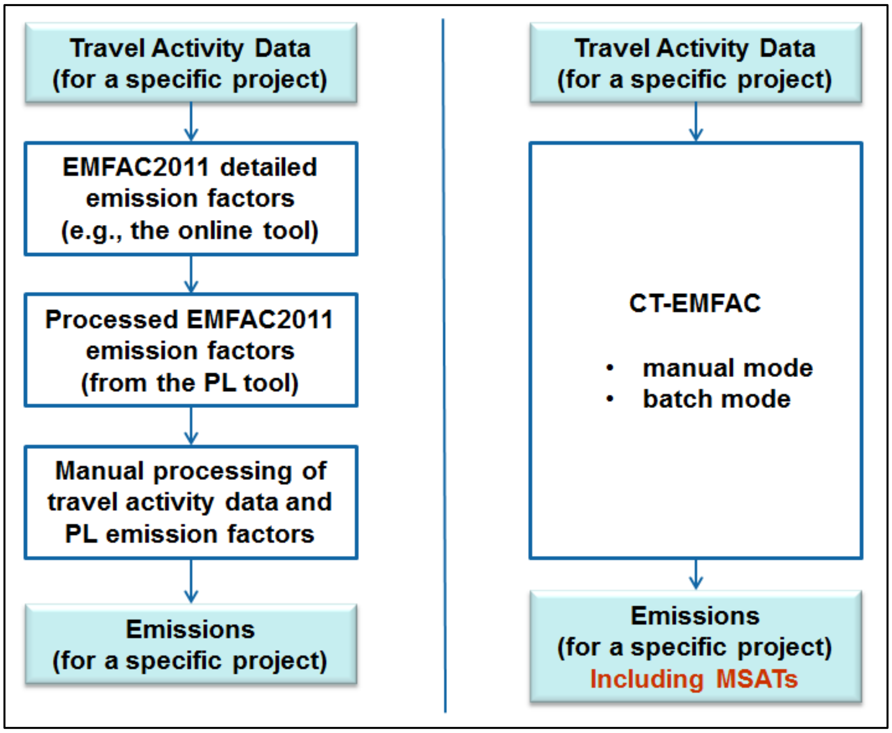


Figure 1. Illustration of key high-level user steps needed to estimate project-level emissions using EMFAC-PL (left) and CT-EMFAC (right). Note that CT-EMFAC embeds, in both its manual and batch modes, steps that need to be manually completed by users running EMFAC-PL.

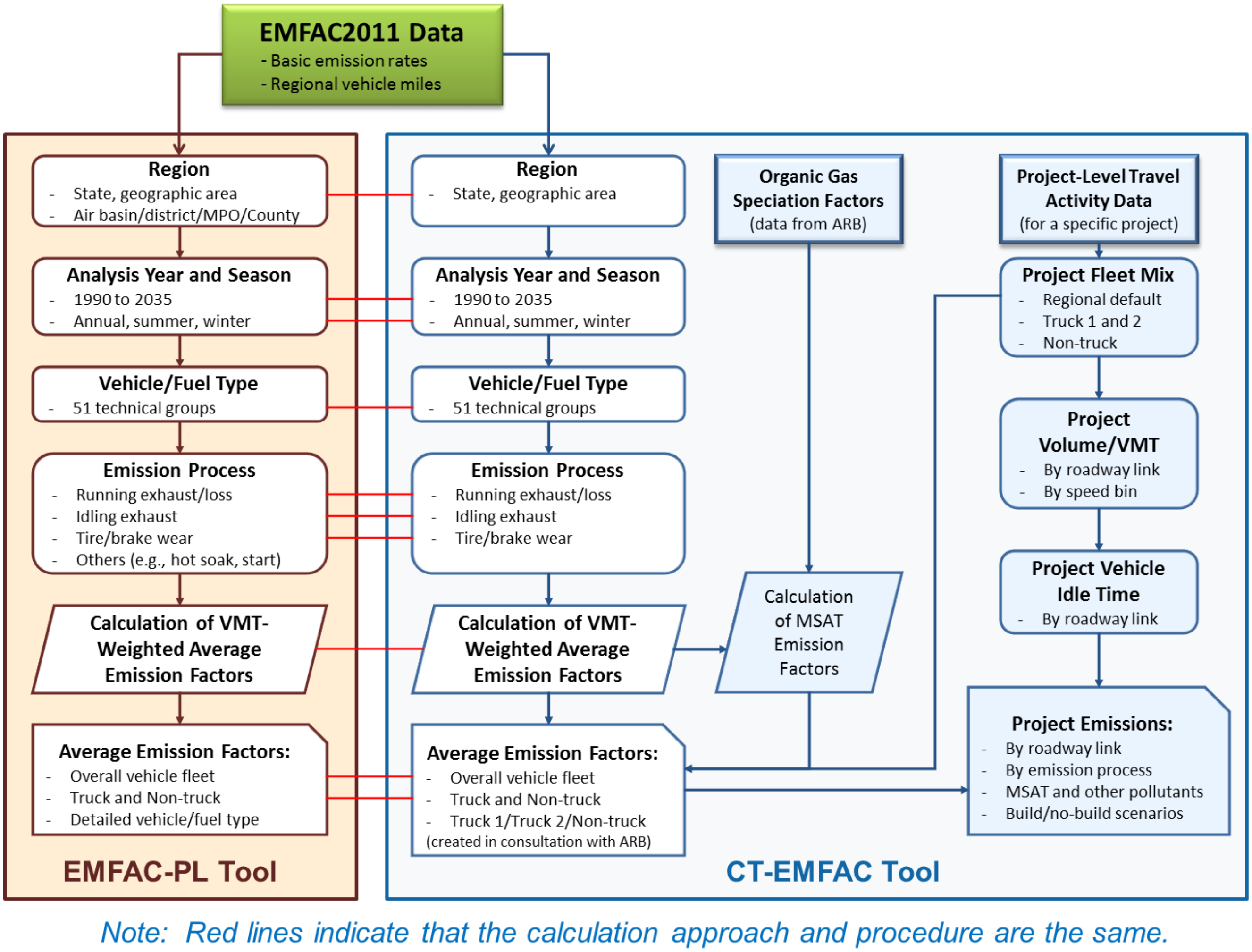
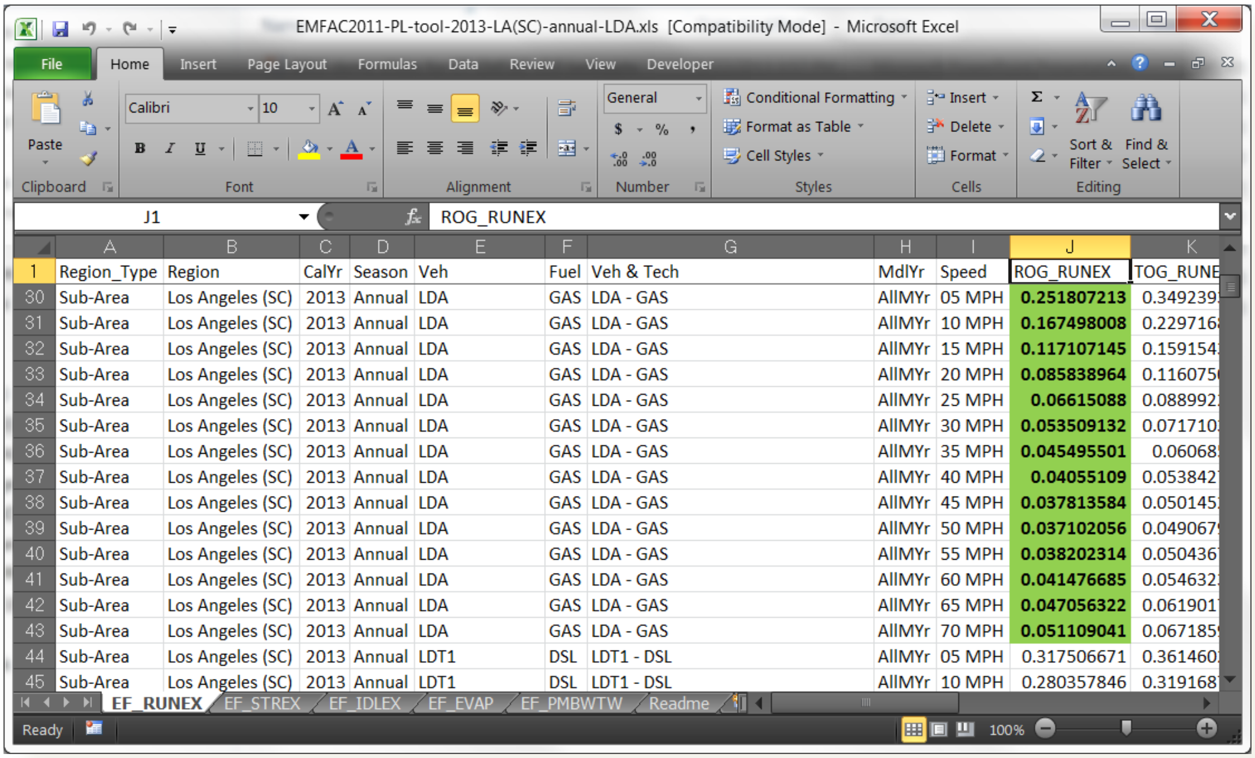


Figure 2. Illustration of how EMFAC2011 data are used by EMFAC-PL and CT-EMFAC. A few EMFAC-PL features are not included in CT-EMFAC, since the transportation project analysis audience served by CT-EMFAC typically does not utilize or need those features. For example, hot soak and start emission factors are not used to estimate project-level emissions for most on-road (link-level) travel activity.

In the rest of this discussion, we use southern California (Los Angeles County) and northern California (San Francisco) case studies to illustrate consistency between CT-EMFAC and EMFAC-PL. For each example, we provide a brief description of the case and then display and explain the data generated by both tools.

Los Angeles County Data Comparison Illustrating CT-EMFAC and EMFAC-PL Consistency

For Los Angeles County, we used EMFAC-PL to produce annual average light-duty auto (LDA) gasoline-powered g/mi emissions factors for a selected calendar year (2013 in this example, although any year from 1990 to 2035 could have been used, consistent with the data available from EMFAC2011). We then compared the emissions factors produced by EMFAC-PL to those included in the CT-EMFAC database for the same year, vehicle type, and pollutants. **Figure 3** presents a subset of the EMFAC-PL findings, using running exhaust emissions results for reactive organic gas (ROG). Model results covered all pollutants produced by EMFAC-PL, however ROG is used here to illustrate findings (the consistency between EMFAC-PL and CT-EMFAC that is discussed for ROG applies to other pollutants as well). As shown in the green area in Figure 3, ROG g/mi emission factors are produced by individual speed bin for speeds of 5 to 70 mph.



	Region_Type	Region	CalYr	Season	Veh	Fuel	Veh & Tech	MdlYr	Speed	ROG_RUNEX	TOG_RUNE
30	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	05 MPH	0.251807213	0.349239
31	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	10 MPH	0.167498008	0.229716
32	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	15 MPH	0.117107145	0.159154
33	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	20 MPH	0.085838964	0.116075
34	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	25 MPH	0.06615088	0.088992
35	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	30 MPH	0.053509132	0.071710
36	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	35 MPH	0.045495501	0.06068
37	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	40 MPH	0.04055109	0.053842
38	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	45 MPH	0.037813584	0.050145
39	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	50 MPH	0.037102056	0.049067
40	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	55 MPH	0.038202314	0.050436
41	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	60 MPH	0.041476685	0.054632
42	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	65 MPH	0.047056322	0.061901
43	Sub-Area	Los Angeles (SC)	2013	Annual	LDA	GAS	LDA - GAS	AllMYr	70 MPH	0.051109041	0.067185
44	Sub-Area	Los Angeles (SC)	2013	Annual	LDT1	DSL	LDT1 - DSL	AllMYr	05 MPH	0.317506671	0.361460
45	Sub-Area	Los Angeles (SC)	2013	Annual	LDT1	DSL	LDT1 - DSL	AllMYr	10 MPH	0.280357846	0.319168

Figure 3. EMFAC-PL gasoline-powered LDA ROG running exhaust g/mi emission factors for the Los Angeles County comparison of data from the calendar year 2013.

Next, we extracted the underlying emissions factors from the CT-EMFAC database for the same case used to generate the EMFAC-PL information: year 2013, Los Angeles County, annual average emissions, gasoline-powered LDA fleet. Results are shown in **Figure 4**.

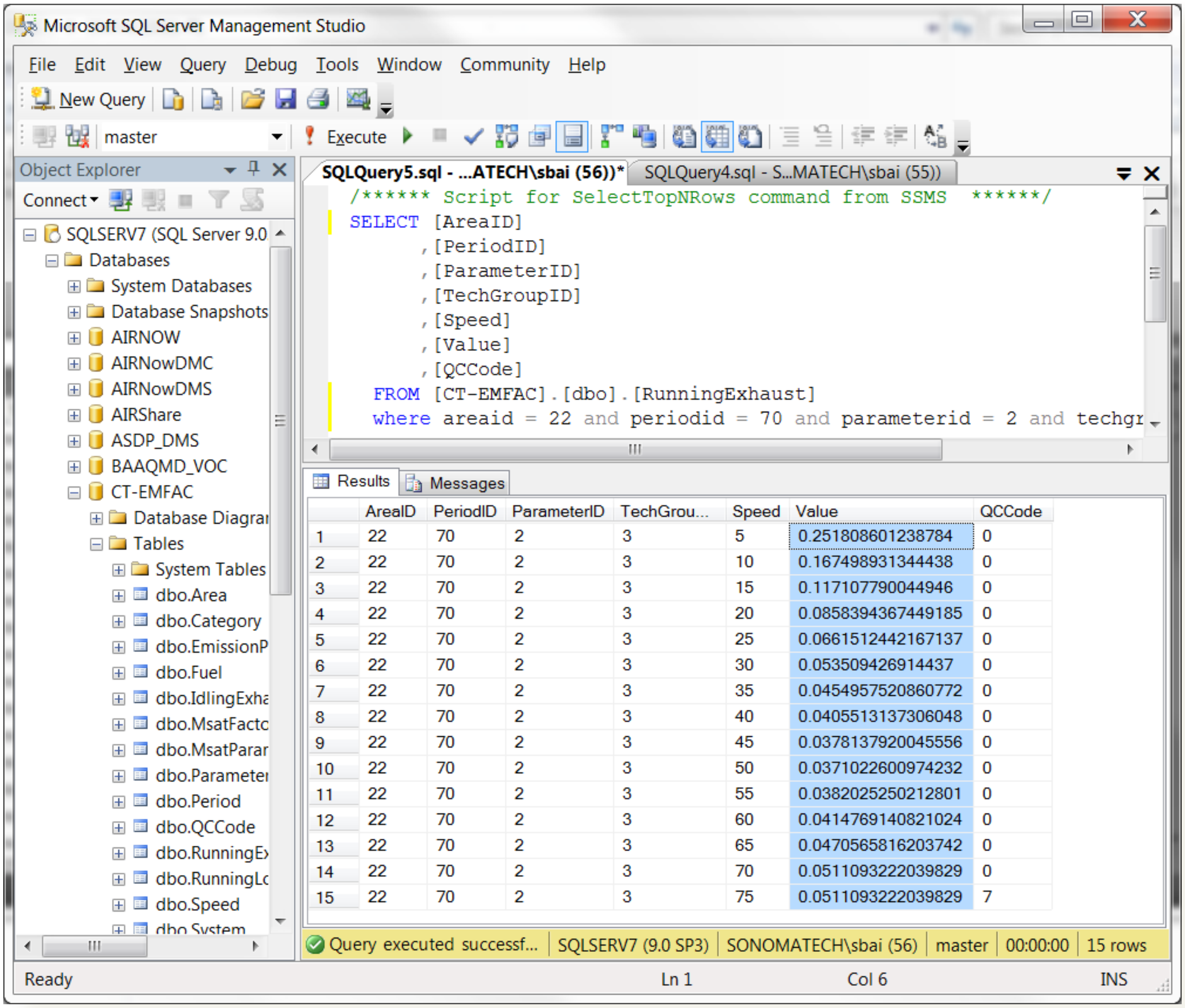


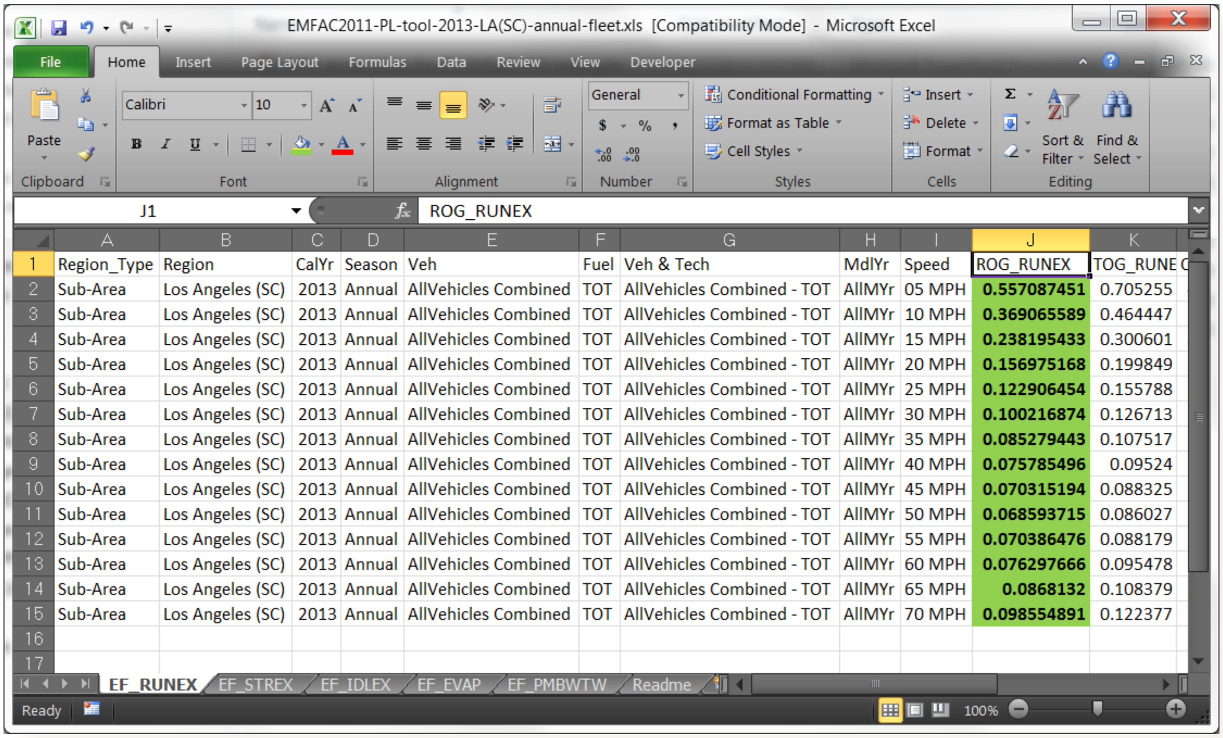
Figure 4. CT-EMFAC database gasoline-powered LDA ROG running exhaust g/mi emission factors, Los Angeles County illustration, calendar year 2013.

Figure 5 presents a comparison of the EMFAC-PL and CT-EMFAC g/mi emission factor results (from Figures 3 and 4). As shown in Figure 5, the emission factors are virtually the same; minor differences can be attributed to rounding in the vehicle miles traveled (VMT) weighting that takes place when developing fleet-averaged emission factors. Note that CT-EMFAC includes g/mi emissions factors for a 75 mph speed bin, whereas EMFAC-PL does not. Some project evaluations involve modeling a small fraction of fleet activity in the 75 mph speed bin. Where EMFAC2011 data were not available to populate that speed bin (or other speed bins), CT-EMFAC development used a data-filling method developed in consultation with CARB (described below in the Handling of Missing Data from EMFAC2011 section).

ROG running exhaust emission factors (g/mi)			
Speed (mph)	EMFAC2011 PL Tool	CT-EMFAC v5.0	% Difference
5	0.25180721	0.25180860	0.001%
10	0.16749801	0.16749893	0.001%
15	0.11710714	0.11710779	0.001%
20	0.08583896	0.08583944	0.001%
25	0.06615088	0.06615124	0.001%
30	0.05350913	0.05350943	0.001%
35	0.04549550	0.04549575	0.001%
40	0.04055109	0.04055131	0.001%
45	0.03781358	0.03781379	0.001%
50	0.03710206	0.03710226	0.001%
55	0.03820231	0.03820253	0.001%
60	0.04147669	0.04147691	0.001%
65	0.04705632	0.04705658	0.001%
70	0.05110904	0.05110932	0.001%
75	N/A	0.05110932	N/A

Figure 5. EMFAC-PL and CT-EMFAC comparison: gasoline-powered LDA ROG running exhaust g/mi emission factors for the Los Angeles County illustration, with data for calendar year 2013.

While Figures 3, 4, and 5 show data for only gasoline-powered LDAs, **Figures 6, 7**, and **8** present similar information for fleet-average g/mi ROG running exhaust emission factors, VMT-weighted to represent activity from all vehicles in the Los Angeles County fleet. As seen in Figure 8, emissions factors from EMFAC-PL and CT-EMFAC are consistent across the entire vehicle fleet, except for minor differences resulting from rounding during calculations.



Region_Type	Region	CalYr	Season	Veh	Fuel	Veh & Tech	MdlYr	Speed	ROG_RUNEX	TOG_RUNE
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	05 MPH	0.557087451	0.705255
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	10 MPH	0.369065589	0.464447
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	15 MPH	0.238195433	0.300601
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	20 MPH	0.156975168	0.199849
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	25 MPH	0.122906454	0.155788
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	30 MPH	0.100216874	0.126713
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	35 MPH	0.085279443	0.107517
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	40 MPH	0.075785496	0.09524
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	45 MPH	0.070315194	0.088325
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	50 MPH	0.068593715	0.086027
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	55 MPH	0.070386476	0.088179
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	60 MPH	0.076297666	0.095478
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	65 MPH	0.0868132	0.108379
Sub-Area	Los Angeles (SC)	2013	Annual	AllVehicles Combined	TOT	AllVehicles Combined - TOT	AllMYr	70 MPH	0.098554891	0.122377

Figure 6. EMFAC-PL fleet average ROG running exhaust g/mi emission factors for the Los Angeles County illustration with data from calendar year 2013.

Los Angeles (SC) - 2013 - Annual.EF - Notepad

File Edit Format View Help

```
       File Name:       Los Angeles (SC) - 2013 - Annual.EF
CT-EMFAC Version:       5.0.0.28175
        Run Date:       1/22/2013 4:34:56 PM
            Area:       Los Angeles (SC)
   Analysis Year:       2013
          Season:       Annual

======================================================================

Vehicle Category        VMT Fraction       Diesel VMT Fraction
                        Across Category   Within Category
       Truck 1                 0.045               0.216
       Truck 2                 0.042               0.907
       Non-Truck               0.913               0.007

======================================================================

Fleet Average Running Exhaust Emission Factors (grams/mile)

       Pollutant Name        5 mph       10 mph       15 mph       20 mph       25 mph       30 mph
                  ROG     0.556235     0.368586     0.237965     0.156896     0.122838     0.100159
                  TOG     0.704292     0.463906     0.300343     0.199761     0.155713     0.126647
                   CO     4.998845     4.133849     3.410210     2.904092     2.564390     2.308228
                  NOx     1.561222     1.204077     0.939809     0.768469     0.711239     0.669363
                  CO2  1435.559326  1088.255005   838.993896   667.853882   561.422180   488.586731
CO2 (Pavley I + LCFS)  1358.688477  1030.958496   794.901855   632.636902   532.127258   463.332947
                 PM10     0.046452     0.033408     0.023774     0.016842     0.014103     0.012265
                PM2.5     0.042672     0.030686     0.021833     0.015462     0.012948     0.011260
              Benzene     0.017029     0.011291     0.007414     0.005032     0.003917     0.003187
             Acrolein     0.000676     0.000462     0.000321     0.000235     0.000181     0.000146
         Acetaldehyde     0.018833     0.011564     0.006440     0.003265     0.002684     0.002244
         Formaldehyde     0.042348     0.026331     0.015101     0.008154     0.006615     0.005496
            Butadiene     0.003318     0.002236     0.001514     0.001071     0.000829     0.000673
          Naphthalene     0.001249     0.000819     0.000560     0.000401     0.000304     0.000242
                  POM     0.000311     0.000215     0.000151     0.000108     0.000087     0.000074
            Diesel PM     0.032743     0.024462     0.017681     0.012476     0.010812     0.009657
                 DEOG     0.224946     0.135950     0.072686     0.033460     0.028040     0.023637
```

Figure 7. CT-EMFAC database fleet average ROG running exhaust g/mi emission factors for the Los Angeles County illustration with data from calendar year 2013.

ROG running exhaust emission factors (g/mi)			
Speed (mph)	EMFAC2011 PL Tool	CT-EMFAC v5.0	% Difference
5	0.55708745	0.55623500	-0.153%
10	0.36906559	0.36858600	-0.130%
15	0.23819543	0.23796500	-0.097%
20	0.15697517	0.15689600	-0.050%
25	0.12290645	0.12283800	-0.056%
30	0.10021687	0.10015900	-0.058%
35	0.08527944	0.08522900	-0.059%
40	0.07578550	0.07574300	-0.056%
45	0.07031519	0.07027700	-0.054%
50	0.06859371	0.06855900	-0.051%
55	0.07038648	0.07035200	-0.049%
60	0.07629767	0.07626100	-0.048%
65	0.08681320	0.08682400	0.012%
70	0.09855489	0.09856100	0.006%
75	N/A	0.09856100	N/A

Figure 8. EMFAC-PL and CT-EMFAC comparison: fleet average ROG running exhaust g/mi emission factors for the Los Angeles County illustration with data from calendar year 2013.

San Francisco Data Comparison Illustrating CT-EMFAC and EMFAC-PL Consistency

In addition to comparing the underlying emission factors used with CT-EMFAC and EMFAC-PL, we also ran a comparison of both tools by generating link-level emissions for a hypothetical road. For this comparison, we developed hypothetical road data for a calendar year 2008 San Francisco scenario. **Figure 9** illustrates the link-level data assumed for the comparison.

CT-EMFAC input variables	Input value	unit
Area	San Francisco	
Year	2008	
Season	Annual	
Truck%	31.3%	
Non-truck %	68.7%	
road length	1.68	mile
Volume	7,980	vehicles/hr
# of hours	7	hrs
Avg. Idling Time	0.3	min/veh
Speed bin (mph)	VMT Distribution	
15	10%	
20	13%	
25	50%	
30	23%	
35	4%	

Figure 9. Scenario assumptions used as input to CT-EMFAC to assess emissions from a hypothetical road link.

CT-EMFAC uses the data identified in Figure 9 as inputs, and then generates project-level emissions. EMFAC-PL does not have tool functions that enable input of travel activity and fleet assumptions, and that output project-specific emissions. Therefore, to compare project analysis results, we manually processed EMFAC2011 g/mi emission factor data (equivalent to what is available from EMFAC-PL) to simulate the CT-EMFAC model run shown in Figure 9. The manual processing involved taking g/mi emission factors for the various vehicle classes represented by CT-EMFAC's truck and non-truck categories, weighting them appropriately for the scenario, developing VMT- and vehicle type-weighted emissions factors by speed bin, multiplying the speed-bin-specific g/mi factors by the travel activity fractions, and summing emissions across speed bins and vehicle types to obtain project-total emissions. **Figure 10** presents the resulting emissions from CT-EMFAC and the manually derived EMFAC2011 post-processing approach.

Pollutant	Emission Process	CT-EMFAC v5.0 (grams)	EMFAC2011 post-processing (grams)	Difference %
ROG	Running Exhaust	25,363	25,405	-0.16%
ROG	Idling Exhaust	1,046	1,047	-0.14%
ROG	Running Loss	13,434	13,426	0.06%
TOG	Running Exhaust	30,321	30,367	-0.15%
TOG	Idling Exhaust	1,282	1,284	-0.13%
TOG	Running Loss	13,434	13,426	0.06%
CO	Running Exhaust	358,629	358,813	-0.05%
CO	Idling Exhaust	11,823	11,837	-0.12%
NOx	Running Exhaust	193,549	194,211	-0.34%
NOx	Idling Exhaust	5,445	5,480	-0.65%
CO2	Running Exhaust	62,727,404	62,752,700	-0.04%
CO2	Idling Exhaust	1,992,689	1,991,619	0.05%
CO2 (Pavley I + LCFS)	Running Exhaust	62,727,421	62,752,700	-0.04%
CO2 (Pavley I + LCFS)	Idling Exhaust	1,992,689	1,991,619	0.05%
PM10	Running Exhaust	5,603	5,630	-0.48%
PM10	Idling Exhaust	93	94	-0.45%
PM10	Tire/Brake Wear	6,052	6,061	-0.16%
PM2.5	Running Exhaust	5,151	5,176	-0.48%
PM2.5	Idling Exhaust	86	86	-0.45%
PM2.5	Tire/Brake Wear	2,443	2,447	-0.16%

Figure 10. Link-level emissions comparison between CT-EMFAC and manually processed EMFAC2011 data.

Handling of Missing Data from EMFAC2011

In some cases, the EMFAC2011 master data from which the CT-EMFAC database was constructed had missing data. The CT-EMFAC development process involved filling these missing data records using approaches developed in consultation with CARB staff, to facilitate project-specific emissions calculations. The entire CT-EMFAC master database includes approximately 67 million data records. Data gaps in the master database were identified using SQL queries and pivot tables (e.g., by comparing number of records by area, period, and technical group). These data gaps were related to missing data in EMFAC2011 (e.g., emission factors for certain geographic areas in certain years) or inapplicable data categories (e.g., no VMT data for certain vehicle types at high speeds). A program was developed to identify and fill data holes in the CT-EMFAC master database, using an extension or replacement approach. For the RunningExhaust data table, a missing emission factor value at a given speed was filled by “extension” (i.e., substituting an adjacent emission factor value, if available). If no adjacent emission factor values were found, the appropriate statewide average value was used as a surrogate. In other database tables (RunningLoss, IdlingExhaust, and TireBrakeWear), substitutions from the statewide averages were used to fill data holes. When extension or replacement was not applicable (e.g., for VMT data), data holes were filled with zero values. The handling of missing data means that, for certain cases where EMFAC2011 has missing data, emission factors may vary somewhat between CT-EMFAC and EMFAC-PL. However, for a given project assessment, the resulting overall project-level emissions estimates are not expected to differ substantively between the two tools.

Conclusion and Availability of Additional Information

CT-EMFAC and EMFAC-PL were both developed using data from the EMFAC2011 model. The CT-EMFAC tool was developed from the perspective of serving the transportation project analysis community, and thus includes several features not available in EMFAC-PL. These features help speed emissions calculations by pairing travel activity data with emission factors, and also by enabling calculation of MSAT emissions. CT-EMFAC was developed in consultation with CARB technical staff responsible for developing EMFAC2011 and EMFAC-PL; the consultation process helped ensure that the CT-EMFAC tool was developed to use data in a manner consistent with EMFAC2011 and EMFAC-PL. Differences between CT-EMFAC and EMFAC-PL are explained by rounding when weighting by VMT and aggregating across vehicle types, and by the data-filling convention used during CT-EMFAC's development to avoid computational problems from missing data in the original EMFAC2011 dataset.

Additional information is available in the CT-EMFAC documentation package included with the CT-EMFAC tool. **Figure 11** presents a screenshot of the documentation interface accessed from CT-EMFAC v5.0.

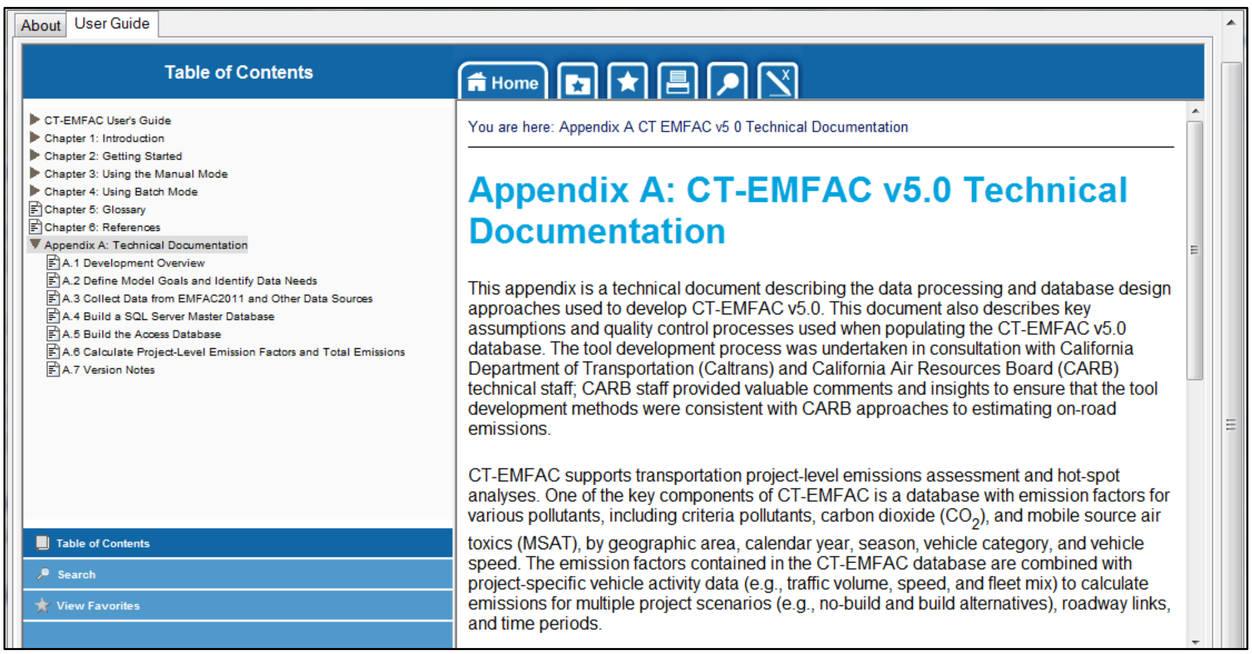


Figure 11. Additional technical information is available from the CT-EMFAC v5.0 interface.